

## **Historic, archived document**

Do not assume content reflects current scientific knowledge, policies, or practices.



**HAWAII AGRICULTURAL EXPERIMENT STATION  
HONOLULU, HAWAII**

**Under the joint supervision of the  
UNITED STATES DEPARTMENT OF AGRICULTURE  
AND THE UNIVERSITY OF HAWAII**

**REPORT OF THE  
HAWAII AGRICULTURAL EXPERIMENT  
STATION**

**1932**



**Issued May, 1933**



**UNITED STATES DEPARTMENT OF AGRICULTURE  
OFFICE OF EXPERIMENT STATIONS**

## HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU

[ Under the joint supervision of the Office of Experiment Stations, United States Department of Agriculture, and the University of Hawaii ]

JAMES T. JARDINE, *Chief, Office of Experiment Stations.*

WALTER H. EVANS,<sup>1</sup> *Chief, Division of Insular Stations, Office of Experiment Stations.*

D. L. CRAWFORD, *President, University of Hawaii.*

---

### STATION STAFF

J. M. WESTGATE, *Director.*

C. P. WILSIE, *Agronomist.*

L. A. HENKE, *Animal Husbandman.*

J. C. RIPPERTON, *Chemist.*

Mrs. LEONORA NEUFFER BILGER, *Collaborator in Research Chemistry.*

W. T. POPE, *Horticulturist.*

CAREY D. MILLER, *Specialist in Nutrition.*

C. J. HAMBRE,<sup>2</sup> *Histologist, Nutrition Investigations.*

C. M. BICE, *Poultry Husbandman.*

H. A. WADSWORTH, *Irrigation Engineer and Soil Physicist.*

D. W. EDWARDS, *Junior Chemist.*

W. C. DAVIS,<sup>3</sup> *Junior Scientific Aid.*

RUTH C. ROBBINS,<sup>4</sup> *Assistant in Nutrition Investigations.*

JOHN CASTRO, *Plant Propagator.*

M. TAKAHASHI, *Assistant in Agronomy.*

G. W. H. GOO,<sup>5</sup> *Assistant in Animal Husbandry.*

### HALEAKALA SUBSTATION

H. F. WILLEY, *Superintendent, Makawao, Island of Maui.*

### KONA SUBSTATION

R. K. PAHAU, *Superintendent, Kealahakua, Island of Hawaii.*

---

<sup>1</sup> Retired Jan. 31, 1933.

<sup>2</sup> Resigned June 30, 1932.

<sup>3</sup> Appointment effective June 1, 1931; resigned May 31, 1932.

<sup>4</sup> Appointment effective Sept. 1, 1931.

<sup>5</sup> Appointment effective Sept. 1, 1931.

# HAWAII AGRICULTURAL EXPERIMENT STATION

HONOLULU, HAWAII

Under the joint supervision of the  
UNITED STATES DEPARTMENT OF AGRICULTURE AND THE  
UNIVERSITY OF HAWAII

Washington, D. C.

May, 1933

## REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION, 1932

### CONTENTS

	Page		Page
Summary of investigations.....	1	Report of the horticultural division—Cont'd.	
Report of the agronomy division.....	3	Pejibaye palm.....	16
Pigeon peas.....	3	Passion fruit.....	17
Green-manure crops.....	4	Papaya.....	18
Forage crops and grasses.....	5	Arboretum.....	18
Soybeans.....	5	Report of the nutrition laboratory of the	
Other crops.....	5	home economics division.....	18
Report of the animal husbandry division.....	6	Japanese foods commonly used in Hawaii.....	18
Dairy cattle.....	6	Vitamin content of Chinese cabbage.....	18
Swine.....	6	Vitamin content of opihi.....	19
Report of the chemical division.....	6	Vitamin B content of rice-bran bread.....	20
Macadamia nut.....	6	Standardization of the use of tikitiki ex-	
Soil investigations.....	7	tract.....	20
Coffee.....	8	Vitamin content of mountain apples.....	20
Grasses.....	11	Biological value of the protein of pigeon-	
Starches.....	11	pea seed.....	21
Report on special chemical investigations on		Report of the poultry husbandry division.....	21
avocado and tobacco.....	11	Sorehead (fowl pox) control in baby	
Sterol content and vitamin value of avo-		chicks.....	21
cado oil.....	11	Sex determination in day-old chicks.....	21
Nicotine content of some tobaccos.....	12	Sugarcane molasses for chicks.....	21
Insecticides from nicotine derivatives.....	12	Papayas, avocados, bananas, and sweet-	
Report of the horticultural division.....	13	potatoes for poultry.....	21
Coffee.....	13	Raising turkeys in confinement.....	21
Macadamia nut.....	13	Report of the soil physics division.....	22
Avocado.....	13	Report of the Haleakala substation.....	22
Citrus.....	13	Plantings at the higher elevations.....	22
Litchi and longan.....	13	Report of the Kona substation.....	22
Akala or native raspberry.....	15	Literature cited.....	23

### SUMMARY OF INVESTIGATIONS

By J. M. WESTGATE, *Director*

The low prices of sugar and pineapples, the leading agricultural products of Hawaii, have stimulated interest in other crops, and in the rather extensive areas of marginal and submarginal lands in the islands whose profitable utilization presents serious problems.

Progress has been made in developing various outlying experimental tracts acquired in 1931. Continuing its cooperative work with the Territorial department of forestry, the station extended its planting to some of the higher elevations on the island of Hawaii where there

are extensive areas that would be benefited by the development of improved crops or by the adoption of agricultural practices especially adapted to these areas.

Experiments were continued during the year on three of the larger islands with pigeon peas; with green-manure, forage, and vegetable crops; and with range grasses. Some 400 new selections of pigeon peas were under test, and progress was made in developing a suitably flavored strain for human consumption. This strain is of especial interest to the many persons on the islands who, to an increasing extent, are growing their food supplies. A bulletin on the pigeon pea, issued during the year (7),<sup>1</sup> covers the work of 25 years with the pigeon pea at the station and the University of Hawaii. Different spacings of the hills in the row were compared in experiments with 64 different green-manure crops, and 10 varieties were uniformly spaced and cut back at different heights to determine the effect on seed production. A nursery containing 145 different species and varieties of grasses and legumes was established, and comparative yield tests of four of the most popular large forage grasses for dairy cows were under way. Experiments with lettuce, potatoes, sweetpotatoes, garden beans, taro, peanuts, ginger, and red peppers were continued.

The eighth year of experiments to determine how feeding sugarcane molasses affected milk yield and breeding records of dairy cows was completed. Tests of the effect of feeding sprouted oats on the breeding ability of dairy cows and brood sows have so far failed to show conclusive results. Feeding of raw sugar as a supplement to fattening rations for swine was continued.

A series of experiments was begun to determine the value of the Mitscherlich pot test as a means of determining the fertilizer requirements of coffee. Studies of the oil content of the avocado were continued. Investigations were begun to obtain nicotine derivatives effective as stomach poisons for certain classes of insects. When grown locally, some strains of tobacco have been found to contain much higher percentages of nicotine than do others. This has an important bearing on the development of the local production of insecticides for use on pineapple fields.

The horticultural work, which is being done at the central station in Honolulu, at the Tantalus substation where the elevation is 1,000 feet, at the Kona substation, Island of Hawaii, where the elevation is approximately 1,500 feet, and at several other places representing material differences in altitude, and in moisture and soil conditions, was primarily concerned during the year with the establishment of new varieties of coffee, Macadamia nut, avocado, citrus, litchi, akala, and passion fruit. Substantial progress was made in developing an economic tropical arboretum. Budding, grafting, and other methods of vegetative propagation of tropical plants were studied.

Studies of the vitamin content of Chinese cabbage, the biological value of the protein of pigeon-pea seed, and the nutritional value of the shellfish locally known as "opihi" were continued, and vitamin studies of the local mountain apple were begun.

It has been demonstrated by the station that sorehead (fowl pox) is transmitted to baby chicks by the mosquito. Vaccination with "live virus" has been shown to be effective against this disease as

<sup>1</sup> Italic numbers in parentheses refer to Literature Cited, p. 23.



early as the fifth week with chicks, the fourth week with turkey poults, and the first week with squabs. Cane molasses was shown to be an economical constituent of rations for both chicks and older fowls. Studies were continued to discover some sex-linked character, readily observed, which would furnish a basis for sex determination of purebred day-old chicks. Cull and surplus papayas, avocados, bananas, and sweetpotatoes were used to advantage as supplements to both laying and fattening rations. Turkeys were raised successfully in confinement when the young poults were vaccinated against sorehead.

The physical significance of the silica-sesquioxide ratios of soil colloids was further studied. The moisture equivalents were found to depend on the amount and the nature of the colloidal material. There appeared to be a definite, direct relation between the silica-sesquioxide ratio and the moisture equivalent of all the soils tested.

Of the 600 or more lots of pigeon peas previously under trial at the Haleakala substation, 100 of the most promising were selected for further comparative test. Tests of numerous grasses, green-manure and root crops, berries, fruits, nuts, and vegetables were continued. Acclimatization and selective breeding work was carried on at different elevations. At Puu Nianiau, where the elevation is 6,400 feet, most of the plantings failed to do well. At the lower elevations most of them succeeded.

Substantial progress has been made at the Kona substation during the two years since its establishment. The work has centered largely on coffee, Macadamia nut, and akala or Hawaii raspberry, but plantings of about 25 different species of fruit and nut trees and plants are under observation. Some work with swine, poultry, and dairy cattle has been started. The substation employs a full-time superintendent who also looks after the outlying experiments under the supervision of the experiment-station specialist in general charge of each particular line of work.

The income of the station for the fiscal year ended June 30, 1932, was increased by \$2,000, the authorized increment of the Adams fund, making the total of the Adams fund allotment \$7,000 for the year. This fund is available only for fundamental scientific research. The total income of the station for the year was \$43,520.

## REPORT OF THE AGRONOMY DIVISION

By C. P. WILSIE and M. TAKAHASHI

### PIGEON PEAS

More than 400 selections of pigeon peas (*Cajanus indicus*) were grown during the year. Many of the individual selections, progenies of single plants of the 1931 season, showed great variability. Fewer than half of them produced progenies of uniform color of flower, pod, and seed. Apparently much natural crossing had taken place in the breeding stocks. Experiments were started to determine the percentage of natural crossing between varieties and strains grown in adjacent-row plats. The need of growing pure strains in complete isolation or of covering the flowers to assure self-pollination was indicated.

-A selection from the Puerto Rico variety Prensado produced pigeon peas apparently of very desirable quality for table use. (Fig. 1.) A planting of this selection is being carefully rogued for variant types, and if a pure strain is established it is to be tested for quality and for yield as compared with the standard varieties. The object of the breeding work is to develop improved strains of pigeon peas for use as green manure, forage, and food.



FIGURE 1.—The Puerto Rico variety of pigeon pea, Prensado.  
Desirable for table use

#### GREEN-MANURE CROPS

A number of green-manure crops were grown to determine the relative amounts of green-top growth produced within six months. *Crotalaria striata* produced at the rate of 18.6 tons (green weight) per acre, and *Cajanus indicus*, 17.6 tons. Species producing much lower yields were *Crotalaria spectabilis*, *C. retusa*, *Canavalia ensiformis*, *Cassia occidentalis*, *C. tora*, and *Tephrosia candida*.

The effect of spacing on seed production was studied with a large number of legumes. Results of two years' experiments indicated that for maximum seed production the plants should be spaced more closely than 6 inches apart, in rows 5 feet apart. The *Crotalaria*s were very promising in seed production, 12 species spaced at the rate of 17,424 plants per acre giving an average yield of 1,433 pounds per acre.



In cooperation with the agricultural extension division, 10 varieties of legumes were grown on each of seven plats in the Kona coffee district in order to study their growth between coffee trees and their relative value as green manure.

#### FORAGE CROPS AND GRASSES

A grass and legume nursery was established during the summer of 1931. Desirable species already growing at the station were transplanted to the nursery, and new species were added to it from time to time. Twelve species of grasses and 40 species and varieties of legumes were introduced from other parts of the world for trial. At the close of the year (June 30, 1932) 45 species of grasses and 100 varieties and species of legumes were growing in the nursery. Observations were made on adaptability of the plants, and on their habits of growth and yield.

Because of the widespread interest of island dairymen in the large forage grasses, an experiment was begun to determine the comparative yields of Napier (elephant) grass (*Pennisetum purpureum*), Merker grass (a form of *P. purpureum*), guinea grass (*Panicum maximum*), and Sudan grass (*Holcus sorghum sudanensis*)—four of the most common and popular of the local forage grasses.

Preliminary studies of Merker grass indicated a difference in color, size, and habit of growth among several strains. Several selections were under test for comparison of desirable features of growth and yield.

#### SOYBEANS

Twenty-five varieties of late-maturing soybeans (*Soja max*) were introduced for trial through the courtesy of the Division of Forage Crops and Diseases of the United States Department of Agriculture, the Missouri Agricultural Experiment Station, and the North Carolina Agricultural Experiment Station. Many of the varieties originally came from China and from Japan. It is hoped that one or more will prove to have superior value as forage or as food for human consumption.

#### OTHER CROPS

Five promising head-lettuce hybrids produced by the station were compared with three commercial varieties. None of the station hybrids showed so high a percentage of solid heads as did the commercial variety Mignonette, locally known as "Manoa," but they gave better results than did the Los Angeles Market (New York) and Hanson varieties. From a segregating  $F_4$  hybrid (accession No. 1801) selections were made for types of good quality which will head well.

One hundred and thirty varieties, hybrids, and seedling varieties of sweetpotatoes grown in small plats yielded at acre rates of 6,000 to 35,000 pounds.

Nine varieties of garden beans, obtained from France in 1928, were grown for comparison with station varieties. Although some were outstanding in vigor and yields, none produced so well as did the three station varieties Kentucky Wonder, a hybrid Kentucky Wonder, and a variety known as accession No. 2291. Kentucky Wonder yielded at the acre rate of 22.7 bushels.

In preliminary tests Guam white corn was promising for table use. It is practically the only variety so far tested that withstands insect and disease attacks at the lower elevations.

Various crops were maintained at the station to serve as sources of planting material and to furnish data on yields.

## REPORT OF THE ANIMAL HUSBANDRY DIVISION

By L. A. HENKE

### DAIRY CATTLE

Experiments were begun in 1924 to determine how rations containing 25 per cent of sugarcane molasses affected the milk yield and reproduction of dairy cows. The experiments involved 87 cows and the results showed a slight decrease in yield of milk and butterfat, and a considerable decrease in reproductive efficiency of the cows on the molasses ration.

Thus far, 25 cows exhibiting irregularity in breeding behavior have been fed sprouted oats and 10 have dropped calves. In two instances the feeding of the oats seemed to be helpful and in six instances the evidence was less definite. Of 24 cows in a control group of cows that exhibited irregularity in breeding behavior but were not fed sprouted oats, 9 have calved. The evidence obtained does not show conclusively that sprouted oats are of value in correcting breeding troubles in dairy cows; it indicates that under Hawaiian conditions, with green feed available the year around, the oats are of little value.

### SWINE

In experiments (6, p. 9) to learn the value of raw sugar in fattening hogs, 81 hogs have been fed rations usually containing 5 to 10 per cent of raw sugar, replacing an equivalent amount of barley in the control ration which consisted of 88 pounds of barley, 8 pounds of tankage, 2 pounds of linseed meal, 1 pound of steamed bone meal, and 1 pound of salt. Green alfalfa was fed to all the hogs. The use of raw sugar in the ration increased the daily gains somewhat and slightly reduced the feed required and the cost per pound of gain.

Of nine sows showing irregular breeding behavior that were fed sprouted oats, six farrowed. The feeding of sprouted oats seemed to be helpful in one case, but in two others the evidence was less definite. Of the eight sows in the control group that were irregular in breeding behavior but were fed no sprouted oats, three farrowed normally and a pregnant sow died. The evidence does not show conclusively that sprouted oats are helpful in improving the breeding behavior of sows.

## REPORT OF THE CHEMICAL DIVISION

By J. C. RIPPERTON and D. W. EDWARDS

### MACADAMIA NUT

Studies of various methods of grading nuts harvested monthly from 12 representative Macadamia-nut trees were carried through a third crop. Certain of the nut characters in the different trees remained remarkably constant, whereas others showed considerable variation. It was found that for a given tree the proportion of culls, mainly immature nuts, may range from more than 80 per cent to less than

1 per cent. The percentage is usually high during the off season and decreases to the lowest point during the months of greatest yields. Nutritional factors are probably chiefly concerned in these differences among trees since they differ greatly from year to year, and in certain instances a tree has continued to drop its crop chiefly as culls throughout the year only to return to normal during the following year.

Further work continued to show inherent differences in the properties of the smooth-shelled and the rough-shelled varieties of Macadamia nut. One orchard of the rough-shelled variety in the Kona district was outstandingly higher in the oil content of the nuts than was any heretofore found, and had relatively few culls. Even with a high oil content, the rough-shelled nuts are noticeably denser and harder in texture. This has an important bearing on their cracking and roasting qualities. Characters such as these are often the determining factors in the selection of commercial varieties of other nuts.

The specific-gravity method of rapidly determining the oil content of the Macadamia nut was further tested and found to be accurate to about  $\pm 0.5$  per cent of oil, with both smooth-shelled and rough-shelled varieties.

Nuts of different specific-gravity groups were roasted to determine the dividing line between first-grade nuts and culls. Heretofore this line has been placed at unity, that is, the specific gravity of water, but nuts of a specific gravity between unity and 1.025 were rated as acceptable in flavor and in texture by most of those who tested them. Nuts having a specific gravity greater than 1.025 were classed as culls.

Since the local Macadamia-nut industry is planning to begin the roasting and exporting of the nuts in the near future, experiments have been started to determine the keeping qualities of nuts processed and stored by different methods and for different lengths of time.

#### SOIL INVESTIGATIONS

The soil and geological survey of the Kona district, conducted in cooperation with the geologist of the Volcano Observatory, United States Geological Survey, was completed and a bulletin entitled, "Survey of the Physical Features That Affect the Agriculture of the Kona District of Hawaii," was published (9). It presents the chief features of the geography, climate, and geology of the district, and includes a colored map that shows the principal lava flows, both the recent and the older ones which have an overlying ash mantle of varying thickness. The map also shows the bounds of the present coffee area. The scheme of classification of the soils of Kona is based on the thickness of the ash mantle and the type of the underlying lava. Microscopic examinations and mechanical analyses of the different soil types were made. The volcanic ash has been completely weathered to a characteristic yellow residue, probably palagonite, whereas little decomposition of the crystallizing lava has yet taken place. This has resulted in relatively high percentages of clay fraction, due to the decomposed ash, and of the coarse fractions down to fine sand, due to the undecomposed lava fragments, but low percentages of the intermediate fine sand and silt fractions. This survey makes evident the large area of pasture or unused land in Kona suitable for coffee and for other crops should future economic conditions justify their development.



## COFFEE

## REJUVENATION OF OLD PLANTINGS

Study of different methods of rejuvenating old coffee plantings in the Hamakua region was continued. Differences resulting from the

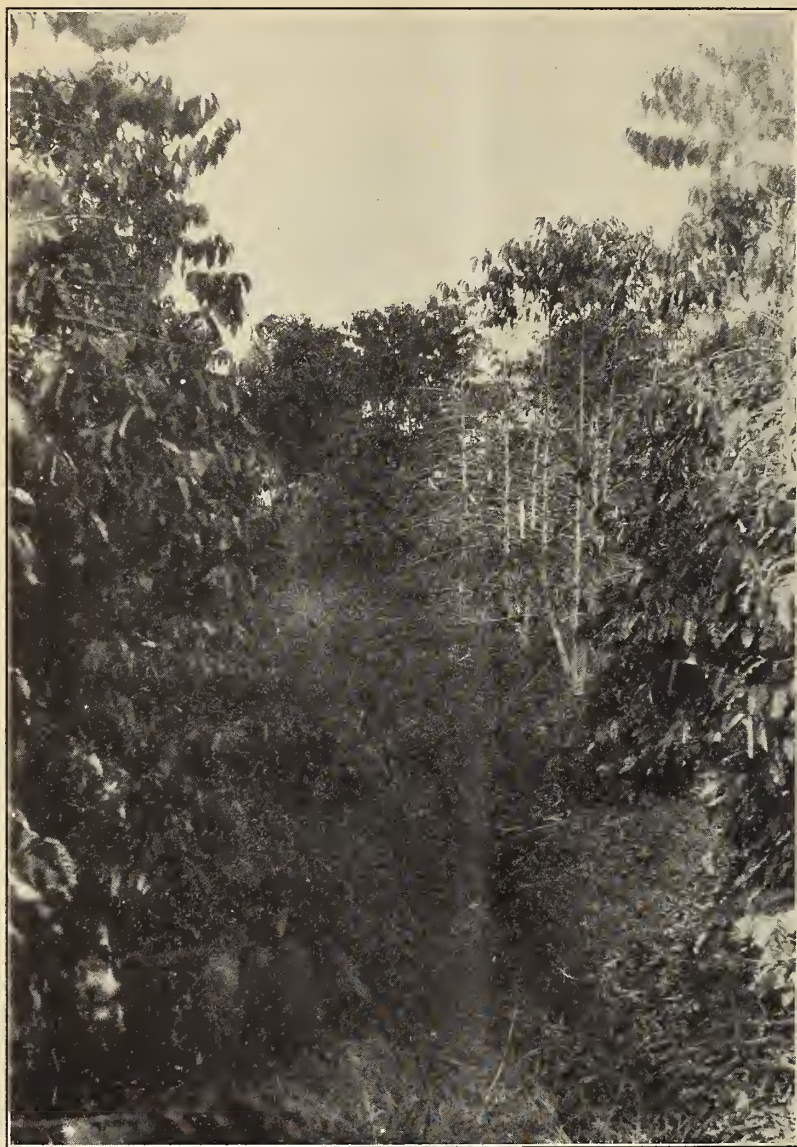


FIGURE 2.—Coffee-fertilizer experiment in Kona, Island of Hawaii. The check plot (right center) is practically denuded. Nitrogen and potash are the most needed elements in coffee fertilization in Kona

several methods tried are now clearly evident. The more drastic the pruning, the more uncertain was recovery. Drastic thinning and pruning back gave excellent results with trees already making normal

growth, but caused a sickly growth and death of some trees which had previously lacked vigor. Cutting off the trunk near the ground resulted in a slender succulent growth of shoots, many of which were not able to support their own weight and broke off readily from the old trunk. The moderately pruned plats produced a fair crop in 1932, thus resulting in the loss of only one crop due to pruning. In the severely pruned plats the vigorous trees produced only a light crop in 1932.

#### FERTILIZER EXPERIMENTS

Two fertilizer experiments with coffee, begun in Kona in 1930, were continued. One carried on in the Kainaliu region, where different fertilizer treatments were begun in January, 1931, showed distinct results in the next crop. The yields of coffee and the growth of the trees showed the superiority of the complete fertilizer (N-P-K) and of nitrogen and potash (N-K) over nitrogen and phosphorus (N-P), nitrogen (N) alone, and no treatment (check plat). (Fig. 2.) The

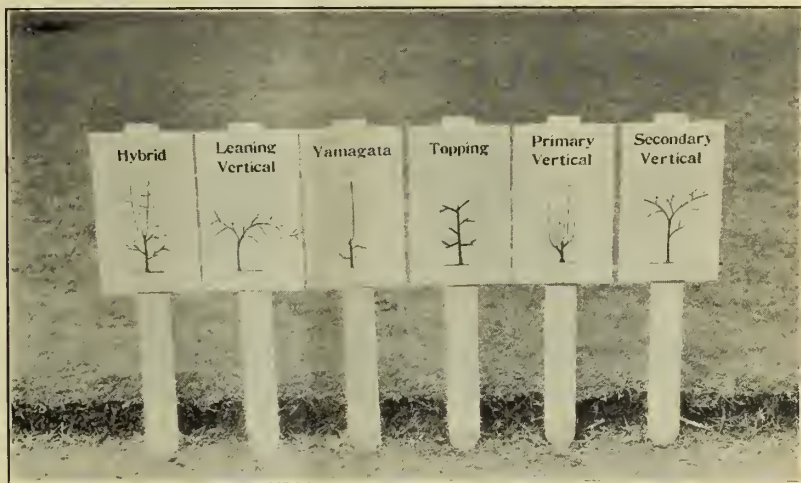


FIGURE 3.—Pruning methods used with coffee in Kona. The heavy lines indicate the permanent parts of coffee trees, and the lighter lines the parts to be removed by pruning. The efficiency of the methods is being compared

results are considered to be tentative, since the effects of sudden change in the treatment may have been extreme. The trees in the poorer plats may adjust themselves to the new treatments and recover. The response to potash is similar to that noted by McClelland (8) in Puerto Rico. A further substantiation of the response to potash was noted in the very high content of potash in the coffee pulp (5 to 7 per cent of potash ( $K_2O$ ) expressed as percentage of dry weight) of the treated trees.

Results of experiments in the Kealahakua region, in which all the plats received uniform fertilizer and cultural treatment, strikingly demonstrated the futility of assigning to a given plat a yield value under the type of pruning (primary vertical) practiced in Kona. Coffee bears only on second-year wood and under the primary vertical method the proportion of the tree in bearing varies widely from year



to year under field conditions. A block of 104 trees was staked off for study of the correlation of tree growth with individual variation in yield.

A study of the comparative merits of different types of pruning practiced in Kona was begun in cooperation with the agricultural extension division of the University of Hawaii at two places in the Konawaena region, one at an elevation of 1,400 feet and the other at an elevation of 1,800 feet. (Fig. 3.)

#### REDUCING PRODUCTION COSTS

The coffee growers of Kona secure yields far in excess of the average for the other coffee-producing countries of the world, but their costs of production are also much higher. With the object of reducing



FIGURE 4.—Testing the availability of plant-food elements in rock and in scoria. Each series of four pots represents one sample. Note the excellent growth of the series 1 and series 2 plants treated with complete fertilizer and with nitrogen and phosphorus; and the markedly poor growth of the plants treated with nitrogen and potash, and with nitrogen. All series 3 plants made chlorotic growth

costs, especially those due to the use of expensive commercial fertilizers, two experiments were begun in Kona at eight places differing widely in altitude and in moisture conditions. In the first experiment, carried on cooperatively with farmers, yields from plots receiving no treatment are being compared with those receiving various amounts up to 1,500 pounds, of commercial fertilizer. In the other experiment different methods of composting coffee pulp and other available organic matter are being studied. Preliminary analyses showed the pulp from 1 acre to be roughly equivalent in value to 400 pounds of high-grade fertilizer. The pulp was high in nitrogen and in potash but low in phosphates.

#### MITSCHERLICH POT EXPERIMENTS

Studies were begun to correlate results from fertilizer experiments with coffee under field conditions with results obtained by the Mitscherlich pot-test method. This method has proved to be of exceptional value in determining the soil needs for sugarcane, but the

extent to which it is applicable to a perennial-tree crop like coffee is problematical. The method is being tried with a number of indicator crops, including coffee. Sudan grass was used as the indicator crop for soils from experimental plats in Kona and in Hamakua. Scoria and freshly crushed and screened rock from typical Kona lavas were also used. Usually the plants in pots receiving nitrogen and phosphorus and those receiving complete fertilizer made normal growth, whereas those in pots given no phosphorus made negligible growth. Attempts to grow second crops in the same material, either from ratoons from old crowns or by reseeding, failed except in pots receiving complete fertilizer. (Fig. 4.)

#### GRASSES

Analyses of grasses from 10 experimental areas on the Island of Hawaii indicated a strong positive response to lime and phosphate fertilizer applications in the grasses from Waipahoehoe and the Volcano plats. The Waipahoehoe grasses showed an increase of nearly 100 per cent in the lime and phosphoric acid content. Grasses from fertilized and unfertilized plats showed generally negligible differences both in amount of vegetation and in percentage of mineral constituents.

Grass gardens were established in many places on the Parker ranch, Hawaii, representing a wide range of climatic conditions. The ranch is cooperating in establishing plats of different grass species in each garden in order to study various questions of culture, behavior, and composition.

#### STARCHES

Analyses to determine the principal cations and anions of 45 starches, including commercial potato, corn, edible-canna, and cassava starch, were completed. Replaceability of the cations was studied by means of cataphoresis and by treatment with salt solutions of varying strengths. The very marked effect of the nature and the amount of the cation on the properties of the starch indicated that determining the cations, either total or replaceable, might serve as an important method of studying causes of fluctuation in the strength of commercial starches. The large amount of work required to develop a satisfactory procedure for a study of replaceability of the cations precluded a comprehensive study of this sort. Preliminary work indicated that a correlation between properties and the nature and amount of the cation exists in edible-canna starches, but not to any appreciable extent in the other species. The rapid decrease in viscosity of edible-canna starch stored for only two or three days was traced to replacement of the potash originally held in the granule with calcium. Electrotitration of a number of electrolyzed starches gave a curve that resembled the titration curve of the neutralization of the first hydrogen ion of phosphoric acid.

#### REPORT ON SPECIAL CHEMICAL INVESTIGATIONS ON AVOCADO AND TOBACCO

By LEONORA NEUFFER BILGER, MARK WESTGATE, and ROBERT LOVELAND

##### STEROL CONTENT AND VITAMIN VALUE OF AVOCADO OIL

Preliminary studies of the oil content of the avocado were brought to a close, and an intensive study of the sterol content and vitamin value of avocado oil was begun.

## NICOTINE CONTENT OF SOME TOBACCOS

Experiments were made to determine at what stage of growth of Hawaii tobaccos the nicotine content is the highest. Young, medium-old, and old tobacco leaves were allowed to dry for several days at 60° C. and then ground fine enough to pass through a 2-millimeter mesh sieve. The pulverized material was dried a second time and transferred to tightly stoppered bottles. Determinations of nicotine were made by methods of the Association of Official Agricultural Chemists (1, p. 55) slightly modified as follows: A weighed quantity of the prepared sample, containing about 0.5 gram of nicotine, was washed into a distillation flask made alkaline with concentrated sodium hydroxide and steam distilled into dilute hydrochloric acid until no nicotine could be detected when the silicotungstic acid test was applied. The distillate was reduced in volume on a hot plate, filtered, and made up to a convenient volume. An aliquot was acidified and treated with an excess of silicotungstic reagent. The resulting precipitate was allowed to stand until crystalline, collected on an ashless filter paper, and ignited in a platinum crucible. The residue was weighed. All determinations were made in duplicate. Table 1 records the nicotine content of four strains of Oahu-grown and one strain of Hawaii-grown tobacco.

TABLE 1.—*Nicotine in different parts of five strains of tobacco*

Strain of tobacco	Proportion of nicotine in—			Strain of tobacco	Proportion of nicotine in—		
	Young leaves	Medium-old leaves	Old leaves		Young leaves	Medium-old leaves	Old leaves
Oahu-grown:	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	Oahu-grown—Contd.	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
No. 2240.....	1.6	1.7	2.4	No. 2243.....	3.0	3.1	3.4
No. 2241.....	3.5	3.8	3.6	Hawaii-grown:			
No. 2242.....	2.2	2.6	2.6	No. 1.....	2.4	2.6	2.3

The table shows that in four of the five cases the nicotine content was lowest in the young leaves, in two cases reached its maximum in the medium-old leaves, and in two cases decreased in the old leaves.

## INSECTICIDES FROM NICOTINE DERIVATIVES

Progress was made in preparing from nicotine an insecticide which kills by stomach poisoning rather than by fumigation. The need for such an insecticide in Hawaii was suggested by R. H. Marlowe, of the Bureau of Entomology of the United States Department of Agriculture. It should be characterized by high toxicity, comparatively low solubility in water, and freedom from objectionable odor and taste. A nicotine supply was obtained from a commercial nicotine-base insecticide by fractional distillation under reduced pressure. The nicotine was converted by the action of an acetic acid solution of bromine into nicotine perbromide. The latter was treated with potassium hydroxide and sulphur dioxide to produce dibromcotinine. Nicotine (2, p. 854; 3, p. 696; 4, p. 574), a compound similar to nicotine and present in tobacco, is in process of preparation. Other compounds prepared, purified, and accepted for experimentation by the Bureau of Entomology were nicotine tartrate, nicotine salicylate



(10, p. 504), nicotine mercuric chloride, nicotine sulphate, nicotine picrate, nicotine benzoyl chloride, nicotine iodide, and nicotinic acid amide.

## REPORT OF THE HORTICULTURAL DIVISION

By W. T. POPE

### COFFEE

Progress was made in cultural experiments with coffee, begun in the latter part of 1930 at the Tantalus substation near Honolulu on Oahu, and at the Kona substation near Kealahou on Hawaii. The coffees under cultivation are Hawaiian, Guatemalan, Robusta (of the robustoid group), and Excelsa, Liberica, and San Ramón (of the Liberian group).

### MACADAMIA NUT

The yield of Macadamia nuts during the year was larger than ever before, because many of the younger trees came into bearing for the first time. From the seedling trees nuts of marked variation, some of them very desirable in form and in quality, were collected. Several grafted trees also came into bearing. Promising trees were selected to serve as sources of scions for vegetative-propagation experiments.

### AVOCADO

Various methods of preserving avocado fruit, extracting avocado oil, and using culls and surplus fruit for feeding swine and poultry were studied at the station and by private growers. At the station 12 varieties of highland avocados from Central America and from Mexico came into bearing, and trees of both seedling and grafted stock were grown at elevations ranging from 1,000 to 6,000 feet in cooperative experiments with ranchers. Most of the introduced varieties are prolific and the fruit compares favorably with that of other varieties grown in Hawaii.

### CITRUS

In a study of methods of protecting citrus trees from attacks by the fruit fly, medium-weight brown-paper bags and medium-weight cellophane bags were used to cover oranges, mandarins, and grapefruit. Two-pound bags were used for mandarins, 3-pound for oranges, and 4-pound for grapefruit. The bags were placed on nearly full-grown fruit showing no trace of yellow color, and most of them remained in good condition for four to seven weeks, at which time the fruit was picked. The bags proved to be too tough to be punctured by the adult female fruit fly, and were seldom torn. The fruit ripened without a blemish, those in the paper bags being lemon colored and those in the cellophane, orange colored.

### LITCHI AND LONGAN

A modified system of air-layering the litchi was tested. Under this system the wounds, caused by girdling the small branches at points where roots were desired, were surrounded with moss alone, held securely in place. A number of 4-inch scions of the variety Kwai Mi were grafted on seedling stocks 17 months old and were 25 per cent successful. (Fig. 5.) The side-tongue method of grafting appeared to give better unions than did the other methods tried.



FIGURE 5.—Kwai Mi variety of litchi grafted on seedling stock of the same species. The side-tongue method gave the most successful union



FIGURE 6.—The giant fruit of the akala, or native raspberry plant



Seedlings of the longan (*Euphoria longana*), a near relative of the litchi, were successfully grafted with the latter.



FIGURE 7.—Cluster of fruit of the pejibaye palm

**AKALA OR NATIVE RASPBERRY**

Further experiments were made with the akala (*Rubus hawaiiensis*; *R. macraei*) (fig. 6) which has been established in the two mountain ranges on Oahu at elevations of 2,300 and 3,600 feet, respectively. Several varieties of the species have been established at the Kona

substation at an elevation of 1,500 feet. A screened house was erected at the substation to protect plants for hybridization from attacks by the Japanese beetle (*Adoretus tenuimaculatus*).



FIGURE 8.—Fruit, flower, and leaves of the sweet granadilla (*Passiflora ligularis*)

#### PEJIBAYE PALM

The pejibaye palm (*Guilielma utilis*), native of Guatemala, received by the station from the United States Department of Agriculture in 1924, recently came into bearing. It produced a cluster of nutlike fruits (fig. 7), from which a number of seedlings were raised. The fleshy portion of the fruit is boiled and used as food.

## PASSION FRUIT

Seven species of the passion fruit, or purple granadilla, were under trial during the year, and several hundred plants were under cultivation at the central station in Honolulu and at the Kona substation.



FIGURE 9.—Papaya plant F. P. I. No. 012608. Note the fruit growing near the ground

The purple passion fruit (*Passiflora edulis*) is used for flavoring salads and sherbets, and for making beverages. The sweet granadilla (*P. ligularis*) is edible in the fresh state. (Fig. 8.)



## PAPAYA

Seeds of papayas from other parts of the world were received for trial. A papaya plant received from the United States Department of Agriculture under the designation F. P. I. No. 012608, proved prolific at an early age. It bears its fruits just above the surface of the ground. (Fig. 9.)

## ARBORETUM

The arboretum of economic tropical plants was enlarged and improved and made increasingly useful to investigators.

## REPORT OF THE NUTRITION LABORATORY OF THE HOME ECONOMICS DIVISION

By CAREY D. MILLER and RUTH C. ROBBINS

## JAPANESE FOODS COMMONLY USED IN HAWAII

A study of the manufacture, methods of preparation, nutritive value, and place in the diet of 26 Japanese foods was completed and the results, including analyses of the foods as grown in Hawaii, were prepared for publication.

## VITAMIN CONTENT OF CHINESE CABBAGE

Raw Chinese cabbage (*Brassica chinensis*) was shown to be an excellent source of vitamin A, 0.0416 gram daily (0.25 gram per week) being sufficient to induce an average weekly gain of 6.5 grams in white rats, using Sherman's method. Approximately 50 per cent of the vitamin A content of raw Chinese cabbage was destroyed in the process of pickling in salt-rice-bran paste. Raw Chinese cabbage was found to be a fair source of vitamin B, 4.5 grams fed daily to standard rats resulting in an average weekly gain of 3.5 grams. Chinese cabbage pickled in salt lost a large part of its vitamin B content. A quantity of salted cabbage equal to 4.5 grams of raw cabbage was not sufficient to prevent an average weekly loss in body weight of 0.5 gram. The vitamin B content was markedly increased when the Chinese cabbage was pickled in salt-rice-bran paste. Eighteen rats, each fed 0.7 gram daily of cabbage pickled in rice-bran salted paste, gained an average of 50 grams in body weight in the eight weeks covered by the test, or 6.2 grams weekly; and 19 rats fed 5 grams daily of plain salted cabbage gained an average of 30 grams in eight weeks, or 3.7 grams per week. This indicated that cabbage pickled with the salt-rice-bran paste contains eight to ten times more vitamin B than does cabbage pickled with salt.

Investigations of changes in the hydrogen-ion concentration of Chinese cabbage showed a decrease from a mean of pH 6.38 for the fresh cabbage to a mean of pH 4.74 for the bran-salted cabbage, or from a nearly neutral point to an acidity satisfactory for the absorption of vitamin B on substances like fuller's earth and Lloyd's reagent. Undoubtedly absorption took place with the transfer of the vitamin from the rice bran to the leaf tissue. Since leaves have a negative charge and vitamin B is a basic substance, conditions for absorption equilibrium in the leaves of Chinese cabbage should be ideal. Details of the hydrogen-ion concentration determinations are shown in Table 2.

TABLE 2.—Determinations of the hydrogen-ion concentration of extracts of Chinese cabbage

Material	Determinations	Mean	Median	Mode	Standard deviation (distribution)	Probable error (minimum)
	Number	pH	pH	pH	Per cent	Per cent
Fresh leaf.....	28	6.38	6.28	6.3	0.36	0.046
Bran-salted water.....	26	4.67	4.62	4.5	.35	.046
Bran-salted leaf.....	38	4.74	4.63	4.5	.35	.038
Plain-salted water.....	37	5.55	5.44	5.5	.72	.080
Plain-salted leaf.....	36	4.91	4.92	4.9	.49	.055

## VITAMIN CONTENT OF OPIHI

Studies of the vitamin A content of the Australian limpet, known in Hawaii as opihi (*Helcioniscus exerata*; *H. argentatus*), were continued. Rats fed 0.2 gram of whole opihi per week gained more than 50 grams in eight weeks. Rats fed 0.05 gram of opihi organs (largely intestines and hepato-pancreas) weekly (equivalent to 0.012 gram dry weight) gained an average of 70 grams in eight weeks, but sometimes the bladder and the kidneys of the rats showed calculi or other disorders, or the animals walked with an unsteady gait, even when the gains were good. Rats fed less than 0.05 gram of organs per week succumbed to infection before the close of the experiment. Rats fed 0.1 gram of organs weekly (equivalent to 0.024 gram dry weight) gained more than 120 grams in eight weeks. Rats fed 0.2 gram of organs per week gained 165 grams in eight weeks. Rats fed, as the sole source of vitamin A, two drops of cod-liver oil per week (equivalent to 0.05 gram) gained an average of 80 grams in eight weeks, whereas rats fed four drops of cod-liver oil weekly (equivalent to 0.1 gram) gained an average of 133 grams. The experiments indicated that the organs of opihi are a much more potent source of vitamin A than is any standard brand of cod-liver oil.

Results obtained with gonads fed separately indicated that the sperm mass is a better source of vitamin A than are the eggs. Rats fed 0.1 gram of sperm weekly gained an average of 75 grams in eight weeks; whereas others fed 0.05 gram per week barely maintained their weight, or gained less than 5 grams in body weight in eight weeks. All rats receiving 0.1 gram of egg per week lost weight in eight weeks, whereas those given 0.2 gram of egg weekly gained an average of 95 grams in eight weeks.

Four grams of opihi fed daily for eight days to rats made rachitic by feeding the Steenbock diet for 21 days gave full protection against rickets as judged by the line test. Two grams daily gave only fair protection. One gram of organs fed daily gave almost complete protection as did also the eggs. One gram of sperm daily gave complete protection. The percentage composition of opihi is recorded in Table 3.

TABLE 3.—Composition of opihi

Material	Moisture	Protein	Fat	Ash	Calcium	Phosphorus	Iron	Copper
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Whole.....	77.20	16.77	1.15	2.76	0.280	0.170	0.01337	0.00023
Egg.....	62.55	23.95	8.71	1.74	-----	-----	-----	-----
Sperm.....	75.95	20.04	2.16	2.45	-----	-----	-----	-----
Organs.....	75.46	12.00	-----	4.59	1.179	.163	-----	-----



## VITAMIN B CONTENT OF RICE-BRAN BREAD

Bread in which 20 per cent of rice bran was substituted for white flour was made by a local baking company for the nutrition laboratory for experimental purposes. Rats fed the rice-bran bread gained an average of 60 grams in eight weeks. However, the results indicated a loss of 25 to 30 per cent of the original vitamin B value of the rice bran. Rice-bran bread sold on the local market was found to contain only half or less than half as much vitamin B as did the experimental bread tested. The rice bran used is essentially like the product technically known as "hullers." Analyses of two samples of this bran showed, respectively, water, 10.15 and 10 per cent; ash, 10.26 and 10.23; fat (ether extract), 20.42 and 20.5; protein (N  $\times$  6.25) 13.63 and 13.2; crude fiber, 8.07 and 8.29; carbohydrates (by difference), 37.47 and 37.78; silica, 0.672 and 0.775; calcium, 0.639 and 0.749; phosphorus, 2.425 and 2.43; and iron, 0.0448 and 0.0363 per cent.

The vitamin B content of local rice bran, good-quality wheat germ, and the best dried yeast that could be obtained, was compared in feeding tests. Rats, fed 0.1 gram of the bran daily, made an average gain in body weight of 64 grams in eight weeks. Those fed 0.1 gram of wheat germ daily made an average gain of 43 grams, and those fed 0.1 gram of dried yeast daily, an average gain of 37 grams.

## STANDARDIZATION OF THE USE OF TIKITIKI EXTRACT

Tikitiki extract<sup>2</sup> probably contains very small quantities of vitamin G, in addition to vitamin B. Experiments were made to learn what was the least quantity that could be fed daily to supply the vitamin B required for good growth in rats. Rats fed 4 drops of tikitiki extract daily as a source of vitamin B gained an average of 125 grams in eight weeks, whereas five paired litter mates fed 3 drops of the tikitiki extract daily gained an average of 104 grams in eight weeks. Although rats receiving 3 drops daily made excellent growth, the dosage was increased to 4 drops for rats on a vitamin G-free diet to supply them with vitamin B. A low vitamin G content was shown when the rats were fed a vitamin G-free diet plus 4 to 8 drops daily of tikitiki extract. The rate of gain on the different amounts was practically the same.

## VITAMIN CONTENT OF MOUNTAIN APPLES

Because of many inquiries about the food value of the mountain apple (*Eugenia malaccensis*), which grows abundantly in the mountainous regions of all the Hawaiian Islands, some preliminary experiments with the fruit were made. Guinea pigs fed 3 and 5 grams of mountain apple daily were found, on post-mortem examination, to have developed severe cases of scurvy. Animals fed 10 grams of the fruit daily showed no gross signs of scurvy, but histological examination of their teeth by the Höjer method proved that this amount was not enough to protect the teeth. Feeding rats 4 grams of the fruit daily as the only source of vitamin A, resulted in a unit gain in body weight of 25 grams in eight weeks. Ten grams daily was not sufficient for a unit gain of 3 grams per week in weight of rats on either a vitamin B-free or a vitamin G-free diet.

<sup>2</sup> The tikitiki extract was obtained from the Philippine Bureau of Science.

**BIOLOGICAL VALUE OF THE PROTEIN OF PIGEON-PEA SEED**

The results of feeding two lots of paired rats pigeon-pea seed meal with and without cystine, as the sole source of protein, did not correlate well with those of previous experiments, and further experiments were undertaken.

**REPORT OF THE POULTRY HUSBANDRY DIVISION**

By C. M. BICE

**SOREHEAD (FOWL POX) CONTROL IN BABY CHICKS**

Results of an experiment begun to learn how sorehead (fowl pox) (identified as epithelioma contagiosum) is transmitted to baby chicks indicated that the disease is spread by the mosquito and may be prevented by screening the runs and houses from the day mosquito (*Aedes (Stegomyia) aegypti*) and the night mosquito (*Culex quinquefasciatus*). In an experiment on the efficiency of a "live virus" vaccine, results were obtained as early as the fifth week with chicks, the fourth week with poults, and the first week with squabs.

**SEX DETERMINATION IN DAY-OLD CHICKS**

Efforts to find some definite sex-linked character in day-old purebred chicks were continued, the characters studied being voice, length of tail, length of wing, internal organs in the vent, position of chick when held by the nape of the neck or by the feet, and color of the legs and the toes in dark-shanked birds.

**SUGARCANE MOLASSES FOR CHICKS**

In experiments with mash and scratch rations containing different percentages of sugarcane molasses, the rations containing 5 and 7 per cent of molasses, respectively, produced good growth and economical gains, and proved more desirable than was the ration fed to the check lot or the ration containing 10 per cent of molasses.

**PAPAYAS, AVOCADOS, BANANAS, AND SWEETPOTATOES FOR POULTRY**

Experiments to determine the relative and the actual feeding value of avocados, bananas, papayas, and sweetpotatoes for laying hens and fattening birds were continued. Avocados were satisfactorily fed to laying hens in amounts not exceeding 15 per cent of the whole ration. Fed as a supplement to egg mash and to scratch grains, sweetpotatoes and bananas were satisfactorily used in such amounts as the birds would consume. Feeding papayas over a long period resulted in decreased annual egg production, and was detrimental to the health of the birds. Results of these experiments were published during the year (5).

**RAISING TURKEYS IN CONFINEMENT**

Experiments to learn whether turkeys can be raised economically in confinement indicated a possibility of success if the poults are vaccinated against turkey pox. The poults were confined in battery brooders until five weeks of age, when they were transferred to the brooder house. They remained in the brooder house until they were 10 weeks old and were then transferred to a semiconfined range with a shelter for roosting. When they were 16 weeks old the turkeys

were placed on a semiconfined range and roosted in the trees. Returns of more than \$5 per bird above feed costs have been obtained by this method.

### REPORT OF THE SOIL PHYSICS DIVISION

By H. A. WADSWORTH

Work in the soil physics division during the year centered around the physical significance of the silica-sesquioxide ratios of soil colloids. Repeated analyses indicated that considerable care and universal standardization of procedure are essential if results from different laboratories are to be comparable. There was some evidence that the percentage composition of the colloidal separate collected on the filter, after the centrifuging of the supernatant liquid over the dispersed soil, depends on the speed of the centrifuge bowl, the size of the orifice admitting the liquid to the bowl, the hydrostatic head, and the duration of sedimentation.

Other studies indicated that the moisture equivalent of a soil depends on the amount and the nature of the colloidal material. In general, if similar colloids are considered, the moisture equivalent is directly proportional to the amount of colloidal material present in the soil. If different colloids in equal amounts are considered, the colloid presenting the higher silica-sesquioxide ratio provides the higher moisture equivalent. This is supported by the findings of other investigators.

### REPORT OF THE HALEAKALA SUBSTATION

By H. F. WILLEY

At the Haleakala substation practical methods of eradicating hono-hono (*Commelina nudiflora*) and manienie or Bermuda grass (*Cynodon dactylon*) from cultivated fields were further developed; selective breeding of the pigeon pea was continued, 100 of the most promising strains being planted for further observation; and trials of various field crops, green-manure crops, fruits, nuts, and vegetables were continued. Distribution of improved propagating material was continued.

#### PLANTINGS AT THE HIGHER ELEVATIONS

At Olinda, where the elevation is 3,500 feet, plantings of many forage and root crops, fruit and nut trees, and vegetables that grow well at the lower substations were repeated. At Ukelele, elevation 4,800 feet, the plantings included pigeon peas, grasses, clovers, vetches, and cereal crops. The Ukelele plantings were largely duplicated at Mountain Paddock (5,500 feet elevation). At Puu Nianiae the elevation (6,400 feet) proved to be too great and the situation too exposed for most of the species that succeed at the lower levels. The pigeon-pea plantings succumbed and of 18 species or varieties of cultivated grasses, *Paspalum urvillei* alone grew satisfactorily.

### REPORT OF THE KONA SUBSTATION

By R. K. PAHAU

Substantial progress was made with the various plantings of field crops, range grasses, coffee, fruits, nuts, and vegetables at the substation established at Kona in 1930. Experiments with coffee and



with range grasses were continued in cooperation with private growers. Berry hybridization and plant acclimatization studies were made at the higher elevations.

## LITERATURE CITED

- (1) ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS.  
1930. OFFICIAL AND TENTATIVE METHODS OF ANALYSIS. COMPILED BY THE COMMITTEE ON EDITING METHODS OF ANALYSIS. REVISED TO JULY 1, 1929. Ed. 3, 593 p., illus. Washington, D. C.
- (2) BEILSTEIN, F. K.  
1899. HANDBUCH DER ORGANISCHEN CHEMIE. Aufl. 3 umgearb., bd. 4, rev., 1821 p. Hamburg and Leipzig.
- (3) ———  
1904. ERGÄNZUNGSBÄNDE ZUR DRITTEN AUFLAGE DES HANDBUCHS DER ORGANISCHEN CHEMIE. Dritter Ergänzungsband, Entsprechend dem Dritten Bande des Hauptwerkes. (Edited by P. Jacobson.) Aufl. 3, bd. 3, 718 p. Hamburg.
- (4) ———  
1906. ERGÄNZUNGSBÄNDE ZUR DRITTEN AUFLAGE DES HANDBUCHS DER ORGANISCHEN CHEMIE. Vierter Ergänzungsband . . . (Edited by P. Jacobson.) Aufl. 3, bd. 4, 1218 p. Hamburg.
- (5) BICE, C. M.  
1932. POULTRY FEED SUPPLEMENTS: AVOCADOS, BANANAS, PAPAYAS, AND SWEETPOTATOES AS SUPPLEMENTARY FEEDS FOR POULTRY IN HAWAII. Hawaii Agr. Expt. Sta. Circ. 4, 24 p., illus.
- (6) HENKE, L. A., and MANEKI, M.  
1932. REPORT OF THE ANIMAL HUSBANDRY DIVISION. Hawaii Agr. Expt. Sta. Rpt. 1931: 7-9.
- (7) KRAUSS, F. G.  
1932. THE PIGEON PEA (CAJANUS INDICUS) ITS IMPROVEMENT, CULTURE AND UTILIZATION IN HAWAII. Hawaii Agr. Expt. Sta. Bul. 64, 46 p., illus.
- (8) McCLELLAND, T. B.  
1926. EXPERIMENTS WITH FERTILIZERS FOR COFFEE IN PORTO RICO: Porto Rico Agr. Expt. Sta. Bul. 31, 34 p., illus.
- (9) POWERS, H. A., RIPPERTON, J. C., and GOTO, Y. B.  
1932. SURVEY OF THE PHYSICAL FEATURES THAT AFFECT THE AGRICULTURE OF THE KONA DISTRICT OF HAWAII. Hawaii Agr. Expt. Sta. Bul. 66, 30 p., illus.
- (10) WATTS, H.  
1899-1902. WATTS' DICTIONARY OF CHEMISTRY. Revised and entirely rewritten by M. M. Pattison Muir and H. F. Morley. 4 v., illus. London.

